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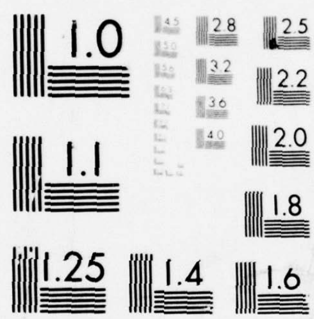

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Report No. FAA-RD-77-64

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Quarterly Technical Summary

Development of a Discrete Address Beacon System

1 April 1977

Prepared for the Federal Aviation Administration by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LEXINGTON, MASSACHUSETTS

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16. Abstract

This is the twenty-first Discrete Address Beacon System Quarterly Technical Summary covering the period 1 January through 31 March 1977. Included are the results to date of analytical studies, laboratory and flight experiments, and software developments supporting the concept feasibility and performance definition phase of the FAA DABS Program.

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CONTENTS

DEVELOPMENT OF A DISCRETE ADDRESS BEACON SYSTEM

I. INTRODUCTION AND PROGRAM OVERVIEW

A. Introduction

This is the twenty-first Quarterly Technical Summary covering work performed by Lincoln Laboratory between 1 January and 31 March 1977 to develop a Discrete Address Beacon System (DABS). This effort is supported by the Federal Aviation Administration through Interagency Agreement DOT-FA72-WAI-261 between the FAA and the United States Air Force.

DABS is an evolutionary upgrading of the present FAA ATC Radar Beacon System (ATCRBS) employing discretely addressable transponders and incorporating a ground-air-ground data link. DABS will provide the improved surveillance and communication capabilities required to meet the needs of an automated ATC system in the 1980's and 1990's.

Under Phase I, Lincoln Laboratory carried out a detailed system design of DABS based upon design studies, trade-off analyses, and experiments. This system design was described in a set of engineering requirements for engineering development models to be designed by the Sensor Development Contractor (SDC), and subsequently evaluated at NAFEC during Phase II of the DABS Program. The completion of these requirements documents represented the nominal completion of Phase I.

During Phase II, Lincoln Laboratory is continuing to support the FAA as DABS System Engineering Contractor (SEC). Major areas of responsibility during this phase include: validation and refinement of the designs specified, assisting the FAA in monitoring the SDC, and using the DABS experimental facility to perform IPC flight tests.

B. Program Overview

Program highlights of the report period were as follows:

(1) Delivery to the FAA of a coordination version of the Proposed DABS National Standard.

(2) A winding down of the TMF field experiments with the return of the Facility to the East Coast, and initiation of DABS sensor netting experiments in conjunction with the DABSEF sensor.

(3) Reduction of TMF taped data to provide monopulse and fade characteristics for the Salt Lake City and Las Vegas airport sites, comparison of elevation lobing performance of the ASR-7 and Cossor antennas at Las Vegas, and traffic distribution and density data for the LA Basin.

(4) Briefing of several FAA groups on the results of IPC flight testing. The essential message of these briefings was: A ground-based separation assurance system is feasible, but the current IPC implementation is unacceptable to pilots – revision of the present set of algorithms is essential.

(5) Continuation of SEC services to the DABS sensor contractor.

C. Report Precis

Sections of this Quarterly Technical Summary contain Phase II task reports as follows:

Section II – Environmental Characterization. Monopulse error and fade measurements made at Las Vegas airport using the TMF are presented. Plots of the reduced data serve as the basis for a quantitative comparison of the Las Vegas site with other potential DABS sensor sites. Constant-altitude, radial flights over the Las Vegas site and the two Salt Lake City sites provided data useful in comparing the elevation lobing patterns of the modified ASR-7 and Cossor beacon antennas. Tables present elevation pattern nulls and their locations for both antennas at each site.

TMF data taped at Brea, California, have been processed to determine typical present-day aircraft distribution and density in the LA Basin. Plots of "Sunday" and "Monday" data, each set referenced to two peak-density locations, depict short-interval total traffic count and graphically illustrate traffic distribution.

Section III – Aircraft Reply and Interference Environment Simulator (ARIES). The ARIES equipment is noted to be well along in its checkout phase; current emphasis is on checking the computer interface and on preparing diagnostic software for various ARIES subunits. A computer program to generate a small, but expandable, traffic model is being written. Parameterized, the constants of this program may be selected at will to increase total number of aircraft and to vary traffic flow patterns represented.

Section IV – Experimental Facilities. Activity reports for each of the facility areas supporting DABS development conclude the QTS. DABSEF effort is diminishing with the termination of IPC flight testing, and the TMF has returned to the East for participation in two-sensor DABS network experiments. Its present location is Warwick, Rhode Island (approximately 50 nmi from DABSEF).

II. ENVIRONMENTAL CHARACTERIZATION

A. DABS/TMF Performance vs Site

1. Site Characterization

TMF site characterization using circumferential flights was carried out at the Las Vegas site in February. These flights were intended to systematically probe the coverage volume and, after data reduction, show any regions of fading or monopulse disturbance, as described in the preceding several DABS quarterly reports.

Bar graphs showing monopulse accuracy and fading for Las Vegas are given in Figs. II-1 and -2. Each bar represents a 3° azimuth wedge, showing in Fig. II-1 the rms value of monopulse errors over that wedge, and in Fig. II-2 the average of the dB fades over that wedge (negative-going for weak signals). Las Vegas is one of those sites, like Los Angeles, at which mountainous terrain eliminates some of the coverage volume. For this reason, it was not possible to fly in a region extending throughout about 180° in azimuth and up to about 1.5° in elevation – the region in which no data is plotted in Figs. II-1 and -2. Otherwise the results are similar to what has been seen at other sites, with monopulse disturbances and fading appearing in certain directions, and with these disturbances generally decreasing at the higher elevation angles. On the whole, the Las Vegas coverage quality is about "medium" among the TMF sites tested – definitely not as good as the results at Clementon and definitely better than the results at LA Airport.

2. Effect of Ground Reflections on Elevation Pattern

Among the TMF experiments performed at Salt Lake City and Las Vegas were tests to determine the effect of in-plane ground reflections on the elevation patterns of both the ASR-7 beacon antenna and the Cossor beacon antenna.

The shapes of the free-space elevation patterns for the two antennas are quite dissimilar and are expected to result in different elevation lobing patterns in the presence of in-plane reflections. The Cossor antenna has a wide elevation pattern with a half-power beamwidth of 44 deg and no vertical pattern shaping, whereas the ASR-7 antenna vertical pattern is shaped to provide a 2-dB per degree rolloff at horizon and a cosecant-squared rolloff above 6 deg. The gain of the ASR-7 at the horizon is approximately 6 dB down from its peak gain of 25 dB at 6 deg elevation.

The elevation pattern of each antenna was measured by recording, in the normal TMF edge event mode, the replies from a discrete-code aircraft flying a prescribed radial flight path at constant altitude. The accompanying amplitude vs range plots were generated via the normal ATCRBS surveillance processing routines at DABSEF.

Elevation patterns were measured at two TMF locations in Salt Lake City. The terrain at Site 1 in the direction of the radial flight is rural flat ground for approximately 3 to 4 miles; beyond is the Great Salt Lake. At Salt Lake Site 2, radials were flown in both the north and south directions. The terrain to the south is very flat for approximately 2 miles; beyond that the salt flats extend for another 8 miles.

The applicable terrain in Las Vegas is flat semi-arid land for approximately 10 miles. The heights of the ASR-7 and Cossor antennas above ground were 32 and 38 ft, respectively.

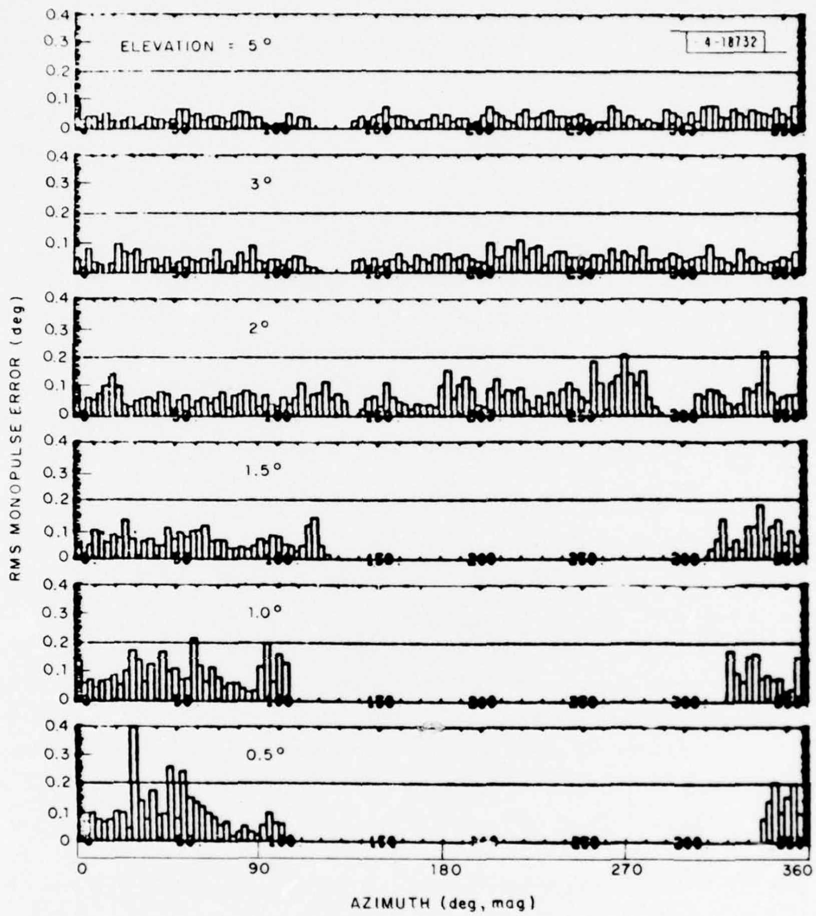

Fig. II-1. Monopulse error vs azimuth for Las Vegas.

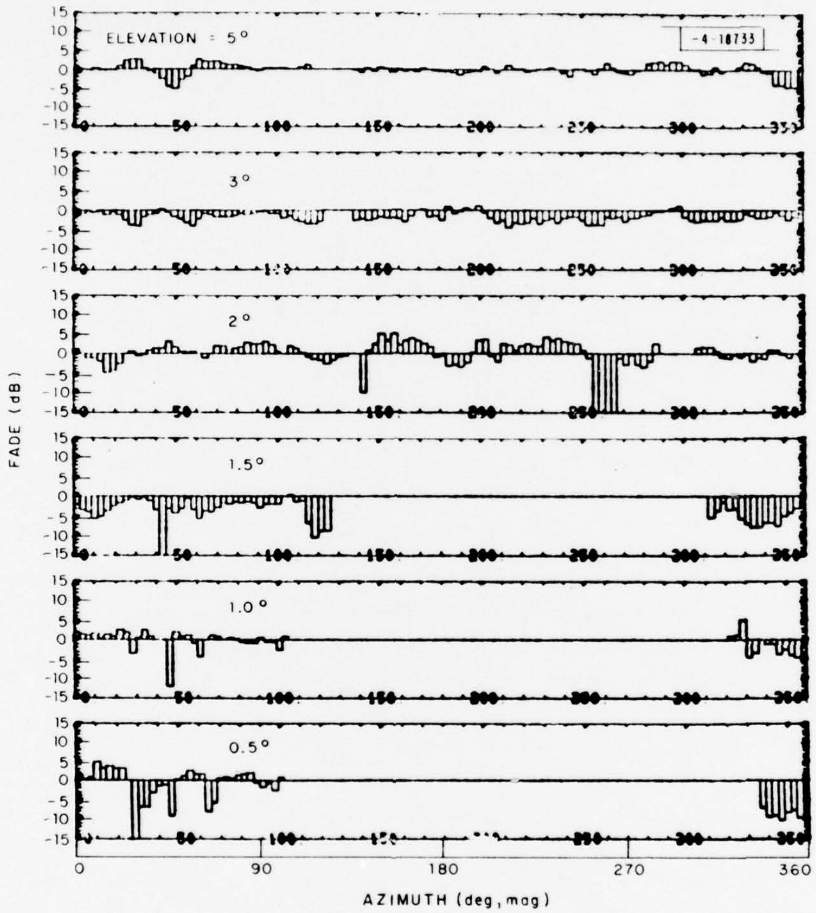

Fig. II-2. Fade vs azimuth for Las Vegas.

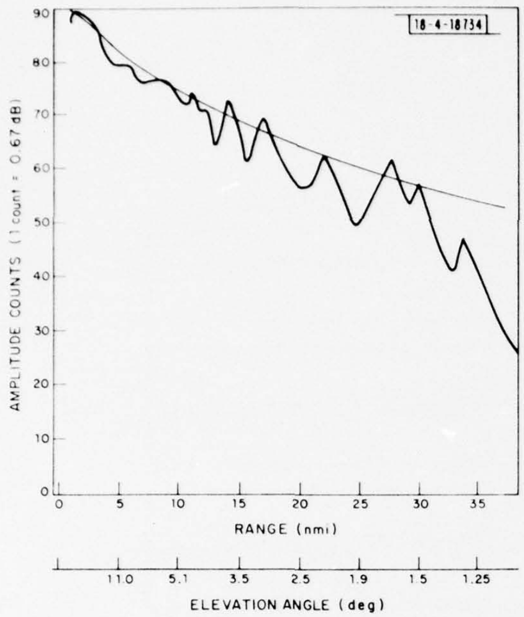

Fig. II-3. Amplitude vs range, ASR-7 antenna, Las Vegas (aircraft inbound at 7500 ft).

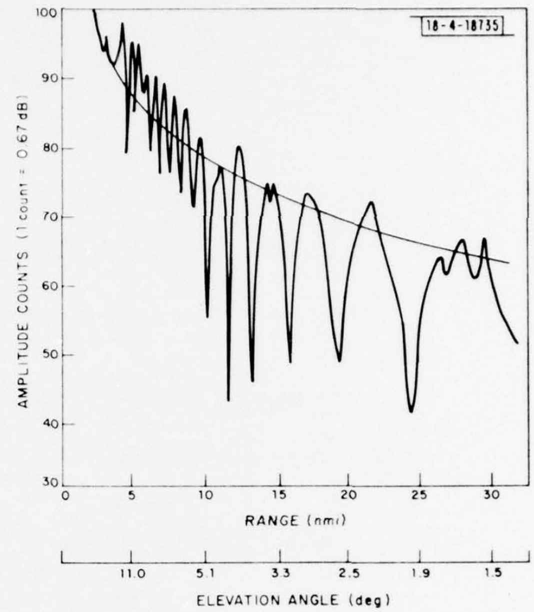

Fig. II-4. Amplitude vs range, Cossor antenna, Las Vegas (aircraft outbound at 7500 ft).

Figures II-3 and -4 are amplitude-vs-range plots for the radial flights performed at Las Vegas and are typical of the plots derived from the other sites. Zero count is equivalent to a received signal strength of −95 dBm with each count being equal to 0.67 dB. The solid curve on the plot depicts the theoretical received signal strength in the absence of multipath induced lobing.

Table II-1 summarizes the depths and elevation positions of the predominant lobing minima for each antenna as measured at the two locations in Salt Lake City and at Las Vegas.

The ASR-7 antenna with its low-angle vertical pattern rolloff exhibits fewer lobing nulls and less severe fading than the Cossor antenna. Lobing present in the ASR-7 vertical pattern is confined to elevation angles of less than 2 deg. Cossor lobing fades are pronounced up to an elevation angle of 5 deg.

The null positions of the minima are identical for both the ASR-7 and Cossor and are more or less consistent from site to site as would be expected because of the similarity in terrain. The elevation spacing of the minima in all cases is 0.6 to 0.7 deg.

B. Analysis of Present-Day LA Traffic Densities

TMF data collected at Brea, California, last November have been processed in order to obtain statistics on aircraft density and distribution in the LA Basin. The Brea site is about 20 nmi inland from the coast, well situated on a terrain peak, about 1500 ft above sea level. Since traffic varies with day of the week, data sets were selected from Monday, 15 November, at approximately 12:30 p.m. PST and from Sunday, 21 November, at 11:30 a.m. PST. In both cases, a data span of 150 scans was selected (approximately 560 sec) and the "range window" was open from 0 to 80 nmi.

TABLE II-1

LOBING MINIMA

Null Position (deg)	Null Depth (dB)	
Salt Lake City Site 1		
	ASR-7	Cossor
0.7	11	15
1.4	8	19
2.0		9
2.7		4
3.4		4
4.1		7
Salt Lake City Site 2 – North Leg		
Null Position (deg)	Null Depth (dB)	
	ASR-7	Cossor
1.1	9	7
1.8	7	15
2.5		6
3.2		7
3.9		8
Salt Lake City Site 2 – South Leg		
Null Position (deg)	Null Depth (dB)	
	ASR-7	Cossor
0.3	–	14
0.8	14	18
1.4	5	15
2.0		7
2.6		9
3.2		8
3.8		11
4.4		12
5.0		12
Las Vegas		
Null Position (deg)	Null Depth (dB)	
	ASR-7	Cossor
2.0	5	18
2.6	5	13
3.2	5	15
3.8		19
4.4		22
5.0		15
5.6		5

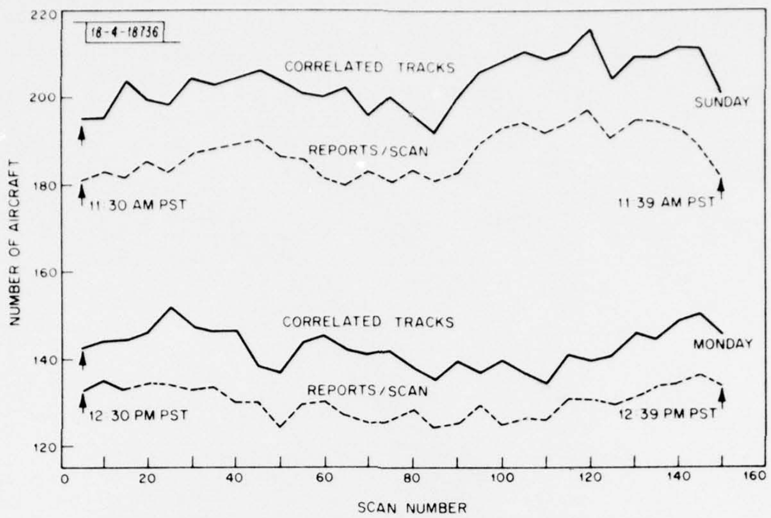

Fig. II-5. Total number of aircraft vs scan number.

The total number of aircraft was determined from "snapshots" of five scans duration. In Fig. II-5, solid lines represent the number of "correlated tracks" defined as follows: tracks receiving at least one correlating report during a five-scan interval. In general, the number of correlated tracks seen during the five-scan interval will be greater than the actual number of aircraft at any instant. Non-discrete codes occasionally generate false tracks of short duration which are counted in the total. Also, the interval over which the count is made is approximately 18 sec in duration. This is long enough to allow aircraft that are taking off or landing to be included in the count although they may not overlap in time. The dotted lines plot the average number of correlating reports per scan during the five-scan period. These represent a lower limit on number of aircraft since all aircraft do not necessarily generate correlating reports every scan. The instantaneous total number of aircraft falls between the two curves.

Using the "correlated track" method of counting aircraft, data from the 30 snapshots were then averaged to obtain a density function in the ground plane. This is presented in Fig. II-6 and is given in multiples of 0.01 aircraft per square nmi taken over a radius of 10 miles. Values are given in hexadecimal (where A = 10, B = 11, etc.) and are truncated by dropping any digits to the right of the decimal point. The maximum value shown is C which represents densities between 0.12 and 0.13 aircraft per nmi^2. This amounts to approximately 39 aircraft within a radius of 10 nmi.

The point of maximum density is (X, Y) = (−10 nmi, −10 nmi) which is near Long Beach. This spot was chosen as the center point for range distribution calculations. Figure II-7 shows the average range distributions in histogram form. Associated accumulative range distributions are given in Fig. II-8 on log-log paper. Figure II-8 indicates that there are 37 aircraft, on the average, within a 10-nmi radius (which is consistent with the symbol C appearing in Fig. II-6). This is the highest traffic density yet observed in any of the TMF data.

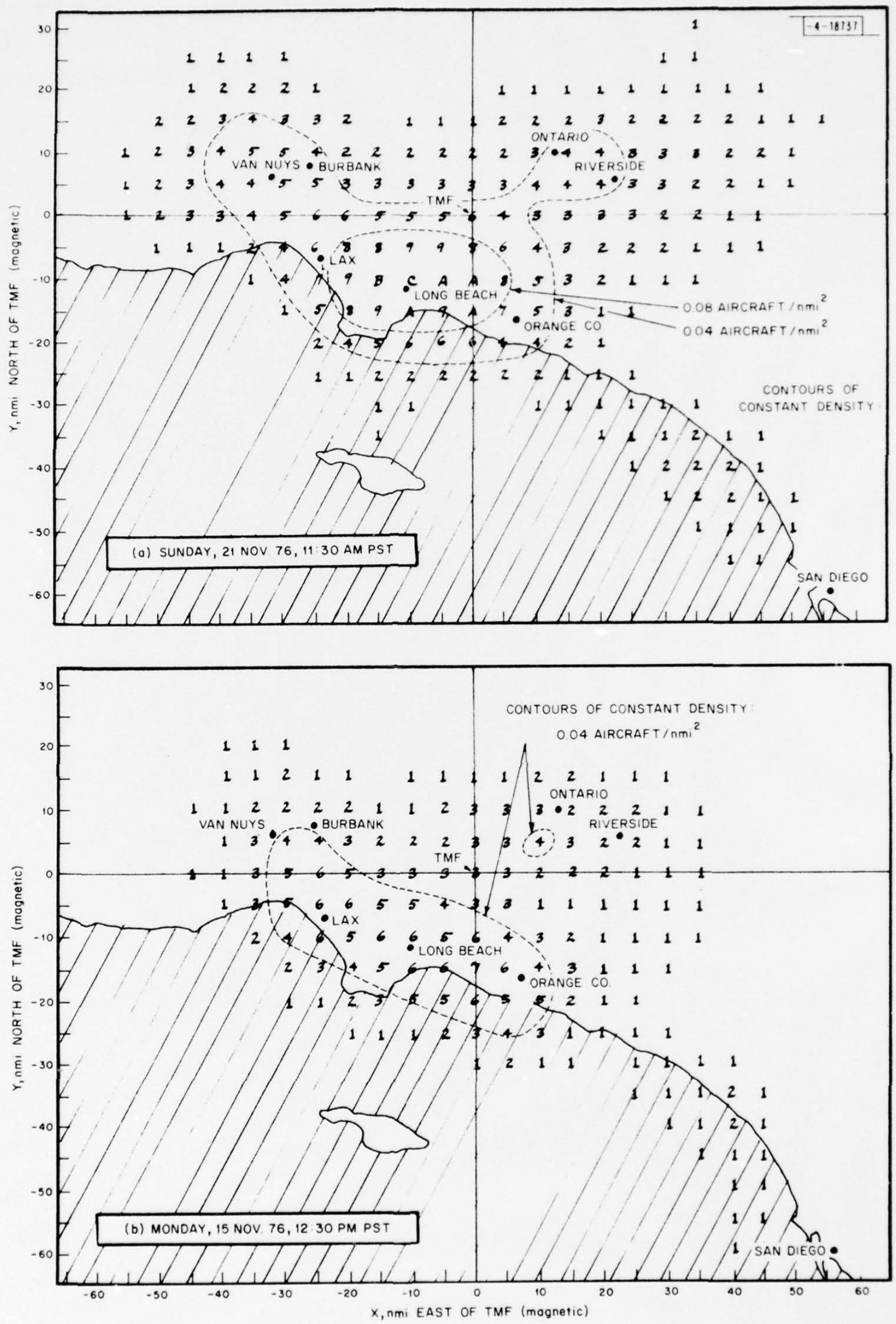

Fig. II-6. LA Basin traffic density maps.

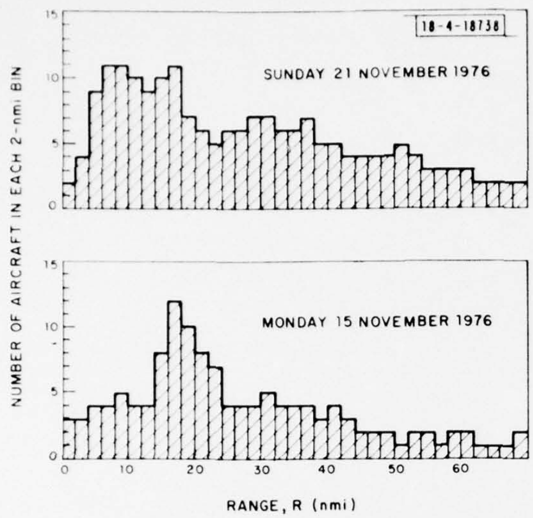

Fig. II-7. Histograms showing ATCRBS traffic distribution about the center point (X, Y) = (−10 nmi, −10 nmi), Long Beach.

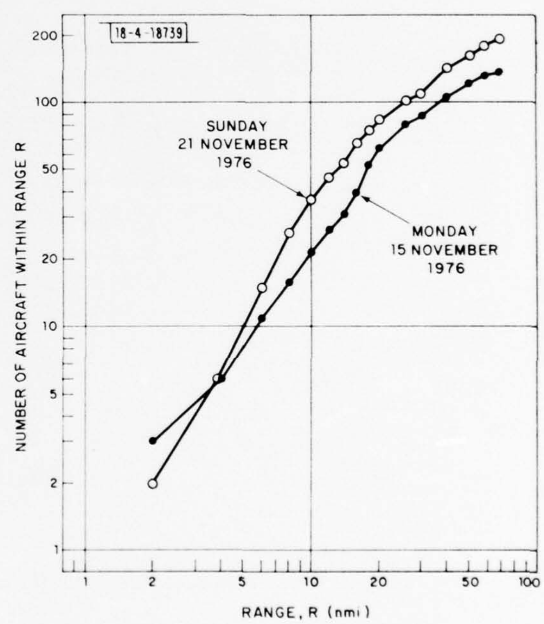

Fig. II-8. Accumulative range distribution of ATCRBS traffic about the center point (X, Y) = (−10 nmi, −10 nmi), Long Beach.

III. AIRCRAFT REPLY AND INTERFERENCE ENVIRONMENT SIMULATOR (ARIES)

A. Development Status

1. Hardware

The ARIES equipment fabrication is now essentially complete, and all drawers have been rack mounted. As of 1 April 1977, the checkout procedure is well along (see 1 January 1977 DABS QTS, Table V-1). All the cards in the digital drawer have been bench checked. The analog drawer also completed the bench check phase during this quarter. A subsystem consisting of one microprocessor, the random process generator, one digital target card, and one analog target card has been configured and used to successfully generate random replies. Some switching transients were observed in the output during this test, and modifications are now being made to the digitally controlled switches and attenuators to eliminate these transients.

The current checkout emphasis is on the computer interface cards. When these are operating correctly, more extensive subsystem tests can be made and computer-based diagnostic programs can be used to more extensively test all the ARIES equipment. For this complete checkout, the ARIES self-test unit must also be used. This unit is now completely fabricated, and its analog components have been bench tested. The digital portion is now in the process of checkout.

During the next reporting period, it is anticipated that the equipment checkout for ARIES will be completed and the system will be moved to DABSEF for final system testing.

2. Software

In the software area, all the microcode for both DABS and ATCRBS/All-Call processing has been completed and tested using software drivers. The rest of the interrogation processing code has also been completed and is ready for testing. This is being deferred until the ARIES equipment checkout is complete.

The major current software emphasis is on writing diagnostic software for the various ARIES devices. This should continue through April and part of May, at which time the emphasis will shift back to the real-time software.

3. Parameterized Traffic Model

The ARIES traffic model is also currently being worked on. For use in system checkout, both at DABSEF and with the DABS sensor being built by Texas Instruments, a "small" traffic model is being generated that starts out with only a few targets initially and grows to around 80 targets. The program that generates this model is parameterized, so a variety of models with different numbers of targets can be generated. This also provides a means to check out the ARIES model conversion software which converts from the MITRE 1982 Los Angeles Basin Model format to ARIES' input format.

IV. EXPERIMENTAL FACILITIES

A. DABSEF

Six AMF experiments, five IPC flights, and two simultaneous TMF experiments were supported by DABSEF during this reporting period.

Initial processing of data from Salt Lake City Site 9; Layton, Utah Site 10, and Las Vegas Site 11 has been completed. Processing for Warwick, Rhode Island Site 12 has begun.

The final version of the SDP was created incorporating the LTAC 5 IPC algorithm, and the final IPC missions were flown using this version. One of the features included in this version and in the playback version was the capability of recording IPC data on ATCRBS/ATCRBS encounters. With this freeze (the twelfth), developmental work on the SDP in support of IPC missions was ended, and any additional software work on this system will be in the form of maintenance.

B. Avionics

Two DABS transponders have been fully updated and shipped to the FAA for distribution to other users. Retrofitting of the remaining transponders to fully reflect all modifications continues.

Termination of the IPC flight program has resulted in less use and therefore less evaluation data from the transponders. TMF measurements and AMF flights have, however, shown up unacceptable performance in multipath environments. Bench simulation of multipath situations has permitted tracing the reduced performance to a specific design feature of the transponder on hand rather than to a general weakness of the system. The specifications in the National Standard have been changed to exclude the design approach which has caused the problem.

A small effort is under way to place a universal display/interface on board the aircraft. The key element in this system will be a microprocessor which manipulates uplink and downlink data resulting in the equivalent of an intelligent airborne terminal. This effort will have major impact on the design of an automated transponder test system because a transponder-microprocessor interface will be established which can be operated for that purpose as well.

C. TMF

On 5 January 1977, the TMF completed its measurements at Salt Lake City Site 1 and was relocated to West Layton, Utah Site 2. The second site, located approximately 17 miles north of Salt Lake International Airport, was evaluated as a possible location for a joint beacon/radar facility for Salt Lake, Hill AFB, and Ogden Municipal Airport.

On 28 January 1977, the TMF was moved to Las Vegas to evaluate the effect on DABS processing of in-beam multipath known to be prevalent there. Figure IV-1 shows the location of TMF at Las Vegas Airport. The TMF completed its activities at Las Vegas on 16 February 1977 and was moved to T.F. Green Airport in Rhode Island where it is currently located (Fig. IV-2). The location in Rhode Island was chosen primarily to support joint DABS netting exercises with the DABSEF facility in Lexington. Table IV-1 summarizes the TMF schedule and recording activity for this reporting period.

D. AMF

The Airborne Measurements Facility is presently assigned to the BCAS flight test program.

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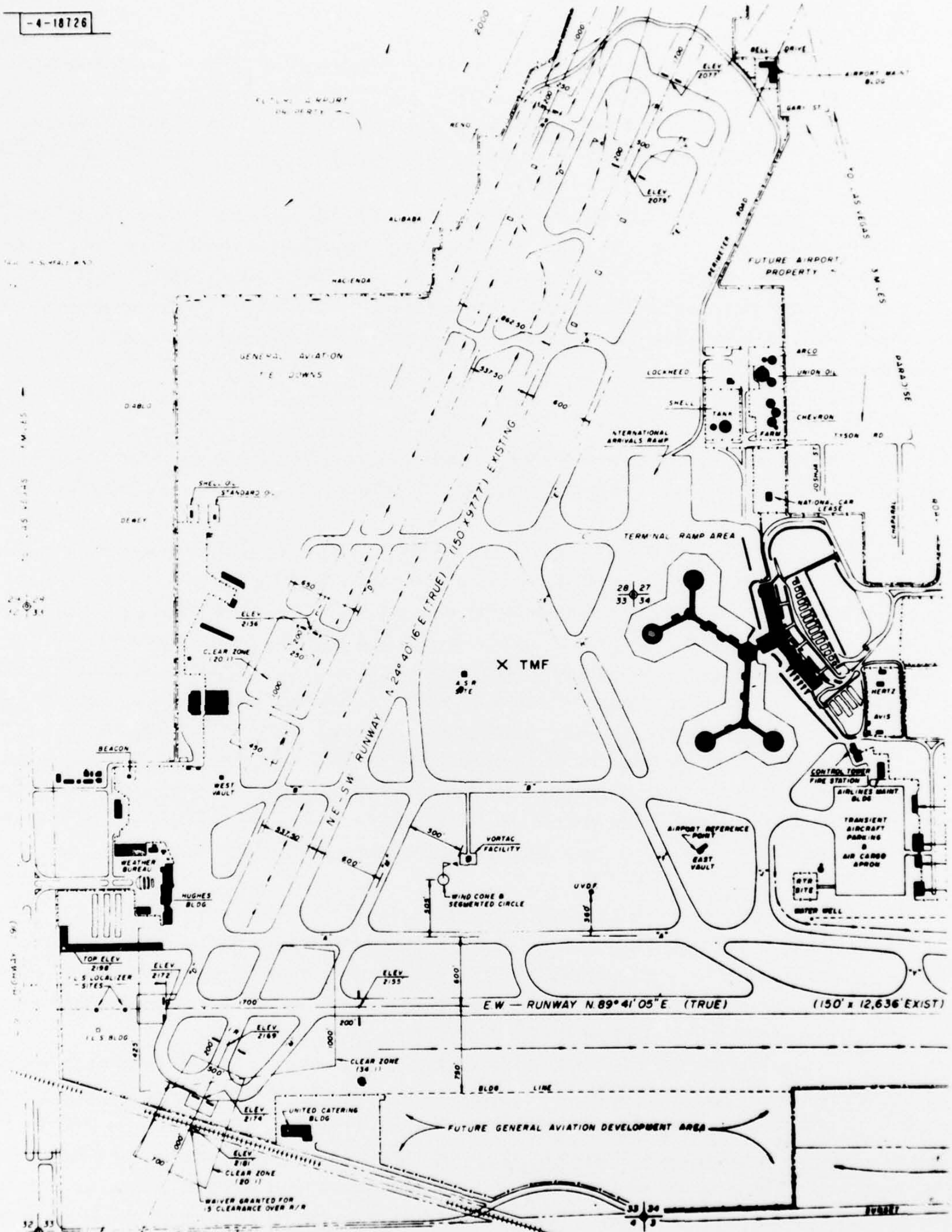

Fig. IV-1. TMF location at Las Vegas Airport.

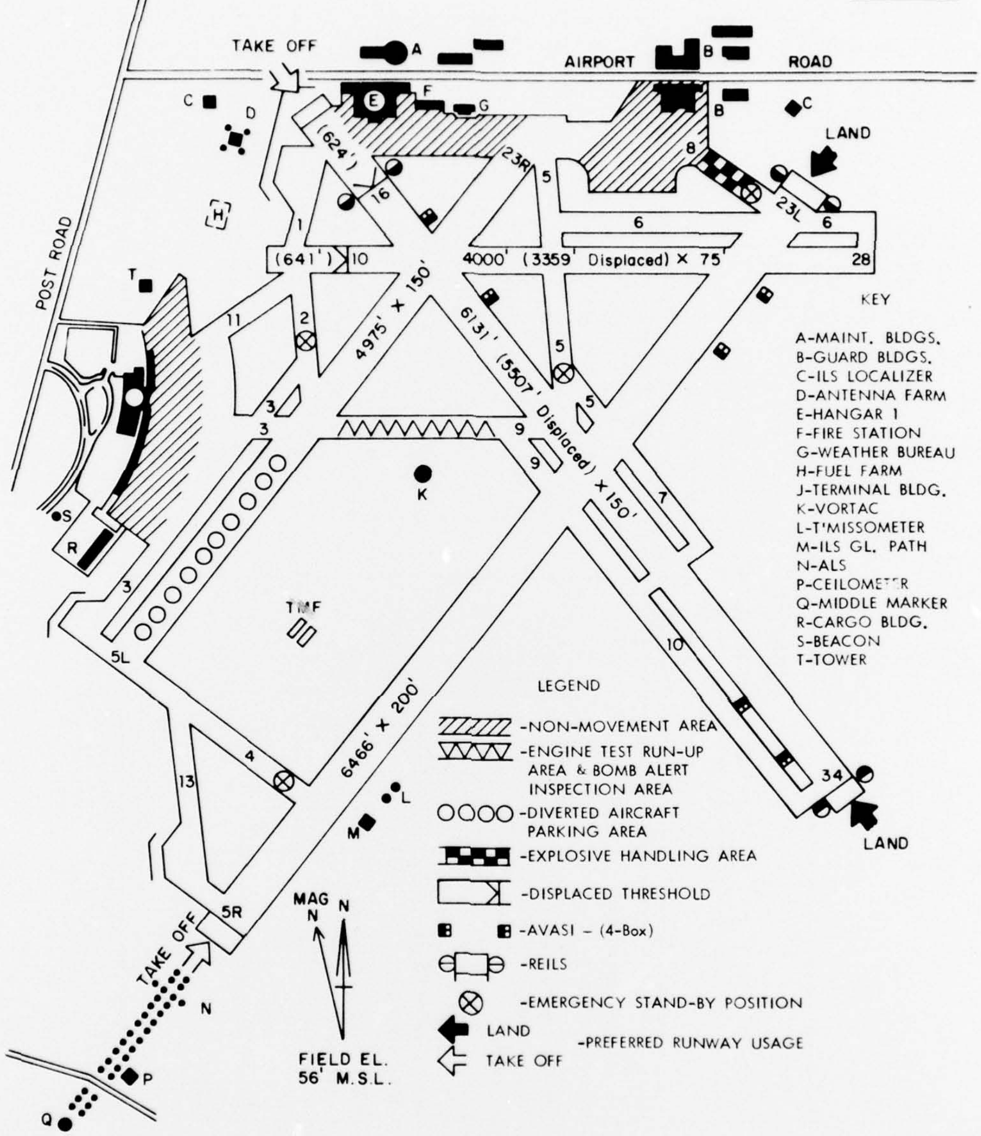

Fig. IV-2. TMF location at T.F. Green State Airport, Warwick, Rhode Island.

TABLE IV-1

TMF RECORDING ACTIVITIES

Experiment	West Layton, Utah 10 to 27 January 1977	Las Vegas, Nevada 1 to 16 February 1977	Providence, Rhode Island 3 March 1977 to Present
Low-altitude coverage involving approaches to two airports	X		
Low-altitude coverage of FAA specified fixes, waypoints, and Victor airways	X		
Vertical lobing experiments	X	X	
TMF-centered circular flights for site characterization		X	
Radial flights of DABS-equipped aircraft to evaluate DABS processing in an in-beam multipath environment		X	
Multi-sensor netting experiments			X
Target-of-opportunity recordings simultaneously with ARTS for performance comparisons		X	X

ABBREVIATIONS AND ACRONYMS

ABIL	Airborne Beacon Interrogator Locator
AC	Air Carrier
A/C	Aircraft
ACS	All-Call to Subset
ACS	Acquisition and Control System (part of SEL-86 computer)
A/D	Analog to Digital
ADC	Air Defense Center
ADIZ	Air Defense Identification Zone
AGL	Above Ground Level
AIMS	Compatible DOD-ATC Beacon System
ALEC	Altitude Echo
AMF	Airborne Measurements Facility
AMPS	ATCRBS Monopulse Processing Subsystem
APG	Azimuth Pulse Generator
ARB	Ambiguity Resolution Bit
ARIES	Aircraft Reply and Interference Environment Simulator
ARINC	Aeronautical Radio, Inc.
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASCII	American Standard Code for Information Interchange
ASR	Airport Surveillance Radar
ATA	Air Transport Association
ATAS	Aircraft Tone and Audio System
ATC	Air Traffic Control
ATCAC	Air Traffic Control Advisory Committee
ATCBI-X	ATCRBS Beacon Interrogator (Model X)
ATCRBS	Air Traffic Control Radar Beacon System
Au	Angle Unit
BCAS	Beacon Collision Avoidance System
BDAS	Beacon Data Acquisition System
BRP	Beacon Reply Processor
C	Climbing
CA	Controller Acknowledgment
CAS	Collision Avoidance System
CAT	Controlled ARIES Targets
CD	Common Digitizer
CDM	Cockpit Display Monitor
CF	Close Fit (algorithm)
CIDIN	Communications ICAO Data Interchange Network
COMM-n	DABS Message Type Designation (n = A, B, C, or D); See FAA-RD-74-62
CONUS	Conterminous United States

CP	Collision Point
CPME	Calibration Performance Monitoring Equipment
CPU	Central Processing Unit
CPV	Correlation Preference Value (NAS)
CRT	Cathode Ray Tube
CRW	Close Range Window
csc^2	Cosecant Squared
CTU	Crosslink Transponder Unit
CW	Continuous Wave
D	Descending
DABS	Discrete Address Beacon System
DABSEF	DABS Experimental Facility
DABSIM	DABS Simulation (software program)
DABSLST	DABS Performance Measurement Program (software)
DAS	Digital Acquisition System (ARTS)
dBI	Decibels With Respect to "Isotropic
dBm	Decibels With Respect to 1.0 Milliwatt
DCAS	DABS-Based CAS
DCFSK	Direct-Coupled Frequency-Shift Keying
DF	Direction Finding
DG	Design Gain
DIM	DABS Interrogation Modulator
DME	Distance Measuring Equipment
DMID	Downlink Message Identification (No.)
DOD	Department of Defense
DOT	Department of Transportation
DOT	Range Times Range Rate (vector "dot" product)
DPSK	Differential Phase-Shift Keying
DRP	DABS Reply Processor
DSF	Digital Simulation Facility (at NAFEC)
DTSD	DABS Traffic Situation Display
DV&R	Design Validation & Refinement
DYNO	A High-Efficiency Interrogation Scheduling Algorithm
ECAC	Electromagnetic Compatibility Analysis Center
EER	Envelope of Error
ELM	Extended Length Message
EN	Envelope of Nulls
E-SCAN	Electronically Scanned Antenna
ER	Engineering Requirement
ERP	Effective Radiated Power
ESC	Experimental Sensor Configuration

FA	Fade Allowance
FAA	Federal Aviation Administration
FAT	Fruit ARIES Targets
FPWI	Flashing PWI (indication)
FR	Full Ring (algorithm)
FSK	Frequency-Shift Keying
GA	General Aviation
GCAS	Ground-Based Collision Avoidance System
GTC	Gain Time Control
HSC	High-Speed Channel (SEL-86 computer)
IAC	Instantaneous Airborne Count
IAR	Interrogation Arrival Rate
ICAO	International Civil Aviation Organization
ICR	Integrated Cancellation Ratio
ID	Identification
IFF	Identification Friend or Foe
IFR	Instrument Flight Rules
IISLS	Improved Interrogation Sidelobe Suppression
ILS	Instrument Landing System
I/O	Input/Output
IPC	Intermittent Positive Control
IRO	Increasing Range Order
LAX	Los Angeles International Airport
LEA	Link Elevation Angle
LED	Light Emitting Diode
LOS	Line of Sight
LR	Link Reliability
LSB	Least Significant Bit
LSI	Large Scale Integrated (-tion)
LTC	Link Test Configuration
Mb/S	Megabits/Second
MCU	Modulator Control Unit
MIL	Military
MILS	Microwave Instrument Landing System
MLS	Microwave Landing System
MNAS	Maximum Number of Sensors
MS	Maximum Number of Sectors
MSI	Medium Scale Integrated (-tion)
MSL	Mean Sea Level
MTDS	Military Tactical Data Systems
MTL	Minimum Triggering Level
MUDSL	Minimum Usable DABS Signal Level

NAFEC	National Aviation Facility Experimental Center
NAS	National Aviation System
NDA	No Data Available
NIKE	United States Army Anti-Aircraft System
NOZ	Normal Operating Zone
NRTCP	New-Real-Time Control Program
NRZ	Non Return to Zero
NRZI	Differentially Encoded NRZ (flux reversal equals "1")
NTDS	Naval Tactical Data System
OAT	Outside Air Temperature
ORW	Open Range Window
OSEM	Office of Systems Engineering Management
PA	Pilot Acknowledgment
PAM	Pulse Amplitude Modulation
PAR	Pulse Arrival Rate
PCA	Positive Control Area
PCD	Production Common Digitizer
PEM	Position Entry Module
PIAC	Peak Instantaneous Airborne Count
PLE	Pseudo Leading Edge
PLL	Phase Lock Loop
PLRACTA	Position Location, Reporting and Control of Tactical Aircraft
PPM	Pulse Position Modulation
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PROM	Programmable Read Only Memory
PRP	Pulse Repetition Period
PSK	Phase-Shift Keying
PWI	Pilot Warning Indicator
QSLS	Quadrature (or Quantized) Sidelobe Suppression
QTS	Quarterly Technical Summary
RAM	Random Access Memory
RAS	Readout; Aircraft State
RBTF	Radar Beacon Test Facility (at NAFEC)
RCC	Regional Control Center
RDJ	Reply Delay Jitter
RIANG	Rhode Island Air National Guard
RIU	Range Interval Unit
RMSE	Root Mean Square Error
ROM	Read-Only Memory
RPG	Random Process Generator

RSLS	Receive Sidelobe Suppression
RT	Round Trip
RTCP	Real-Time Control Program
Ru	Range Unit
S&C	Surveillance and Communication
SAR	Suppression Arrival Rate
SAW	Surface Acoustic Wave
SCP	Surveillance and Communication Processor
SDC	System Development Contractor
SDP	Sensor Demonstration Program
SEC	System Engineering Contractor
SEL	System Engineering Laboratory, Inc.
SIF	Military IFF
SIR	Signal-to-Interference Ratio
SLS	Sidelobe Suppression
SM	Short Message
SMR	Signal-to-Multipath (Signal) Ratio
SNR	Signal-to-Noise Ratio
SPI	Special Pulse Identification
SPM	System Program Manager
SPWI	Steady PWI (indication)
SQV	Sampled Quantized Video
SRDS	System Research and Development Service
SS	Sum of Squares
SSF	System Support Facility (at NAFEC)
STC	Sensitivity Time Control
SWD	Sliding Window Detector
TACAN	Military Aircraft Navigation System (Providing Range and Bearing from Station)
TAD	Technical Acknowledgment, Downlink
TATF	Terminal Automation Test Facility (at NAFEC)
TAU	Technical Acknowledgment, Uplink
TCA	Terminal Control Area
TCR	Transmit Control Register
TDP	Technical Development Plan
TMF	Transportable Measurements Facility
TOA	Time of Arrival
TOD	Time of Day
TSC	Transportation Systems Center, DOT, Cambridge, Mass.
TTL	Transistor-to-Transistor Logic
TWG	Transmit Waveform Generator
UMID	Uplink Message Identification

VFR	Visual Flight Rules
VOR	Very High Frequency Omnirange (Provides Bearing Data)
VORTAC	Combined VOR and TACAN Facility
VPQ	Video Pulse Quantizer
V/STOL	Vertical/Short Takeoff and Landing
ZFLAG/ FLAGSTAT	ATCRBS Performance Measurement and Diagnostic Program (software)
ZRT	Zero-Range Trigger

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FAA-RD-72-44	QTS 1	1 April 1972	Development of a Discrete Address Beacon System
FAA-RD-72-76	QTS 2	1 July 1972	Development of a Discrete Address Beacon System
FAA-RD-72-117	QTS 3	1 October 1972	Development of a Discrete Address Beacon System
FAA-RD-73-12	QTS 4	1 January 1973	Development of a Discrete Address Beacon System
FAA-RD-73-48	QTS 5	1 April 1973	Development of a Discrete Address Beacon System
FAA-RD-73-101	QTS 6	1 July 1973	Development of a Discrete Address Beacon System
FAA-RD-73-165	QTS 7	1 October 1973	Development of a Discrete Address Beacon System
FAA-RD-74-8	QTS 8	1 January 1974	Development of a Discrete Address Beacon System
FAA-RD-74-85	QTS 9	1 April 1974	Development of a Discrete Address Beacon System
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